# Speech Alarms Pilot Study

## Human Research Program
## Space Human Factors & Habitability- Space Human Factors Engineering

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## Introduction

Speech alarms have been used extensively in aviation and included in International Building Codes (IBC) and National Fire Protection Association's (NFPA) Life Safety Code. However, they have not been implemented on space vehicles. Previous studies conducted at NASA JSC showed that speech alarms lead to faster identification and higher accuracy.

This research evaluated updated speech and tone alerts in a laboratory environment and in the Human Exploration Research Analog (HERA) in a realistic setup.

## Lab Study

This study measured alarm identification time and errors for 4 alerts: two emergency, a warning, and a caution alert presented as both speech and tone.

### Subjects
- N = 24
- Normal hearing
- Recruited through the Test Subject Facility

### Method
*Stimuli*
- Tone alerts as currently defined by the HSIR (see Alert Definition section).
- Speech alerts using word repetitions specific to the alert type, e.g., "Fire! Fire!".

*Conditions*
- Alerts without background noise
- Alerts with communication loop noise
- Alerts with fan noise

### Task
Participants listened to an alarm and were asked to identify it as quickly and accurately as possible by clicking the corresponding icon, see Figure 1.
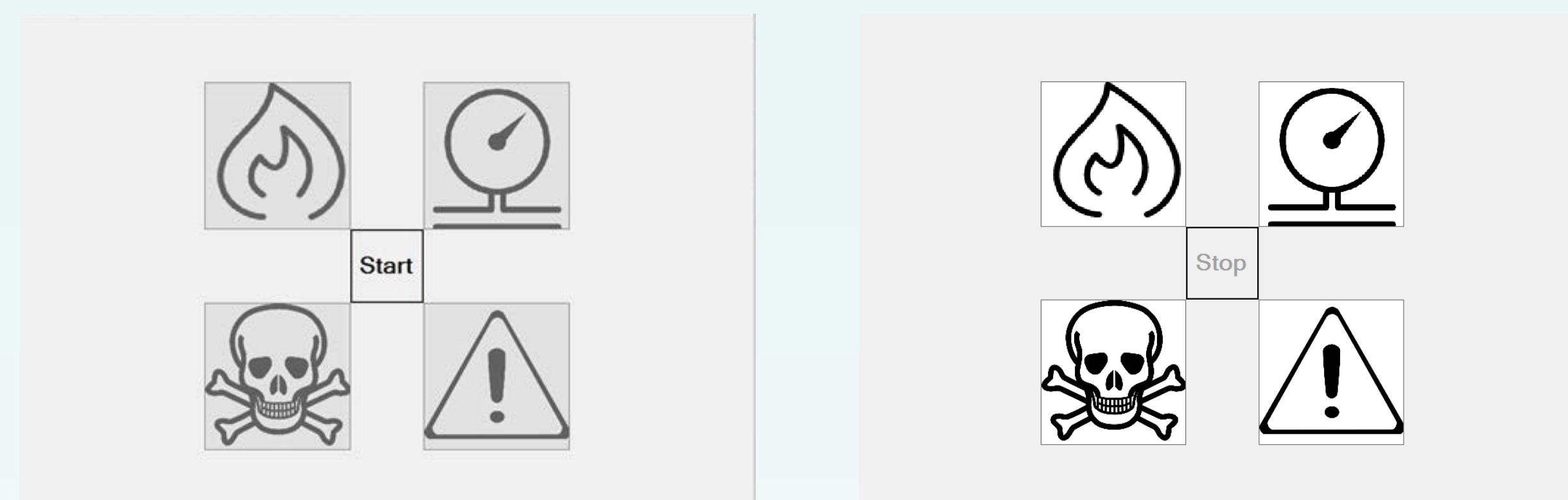


Figure 1. Software screenshots for the task.

## Results

The incorrect trials were removed from the data set. Response times larger than 5000 ms (12 trials out of 6636 correct trials) were excluded as outliers.

A repeated measures ANOVA was conducted on response time. There was a significant main effect of noise condition, $F_{(2,22)}$, = 3.76, $p$ = 0.039. There was also a significant main effect of alarm type, $F_{(1,23)}$, = 20.15, $p$ < 0.001. That is, speech alarms were identified faster than tone alarms (mean diff 203 ms). The interaction was not significant, $F_{(2,22)}$ = 0.86, $p$ = 0.43.



Figure 2. Bar chart showing the mean response times as a function of noise and alert type.

Alarms with voice or fan background noise were identified slower than alarms without background noise, mean RT difference of 38 ms, $t_{(23)}$ = 2.2, $p$ = 0.02 and mean RT difference of 37 ms, $t_{(23)}$ = 2.1, $p$ = 0.04, respectively. There was no difference in RT to alarms with communication loop and fan background noise, $t_{(23)}$ = 0.03, $p$ = 0.97.

Overall, participants were more accurate identifying speech alerts than tone alerts, $t_{(22)}$, $p$ = 0.004, mean difference of 3 errors.
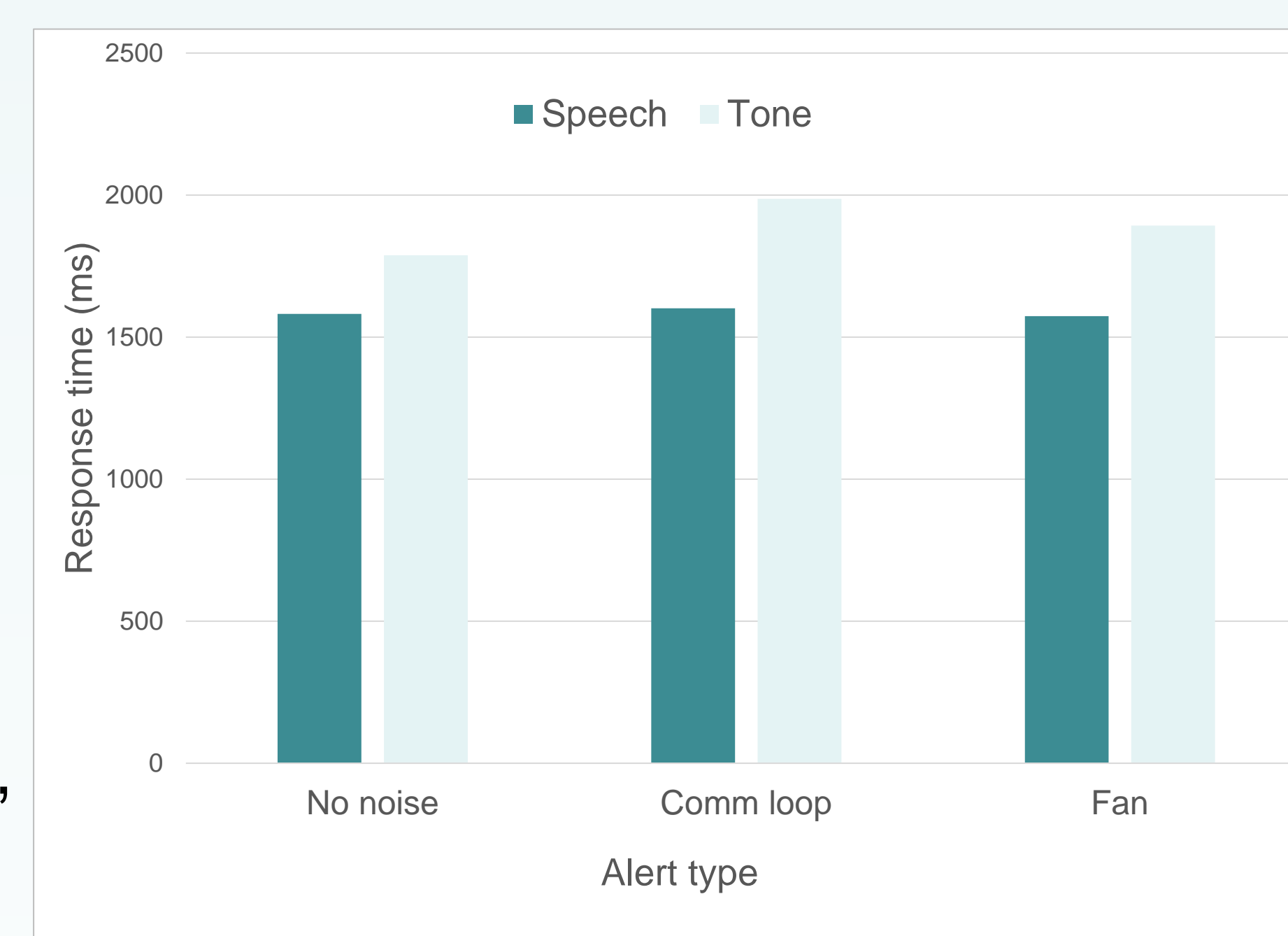
## Alert Definitions from Human System Integration Requirements
- <u>Emergency</u>: Specifically identified life threatening warning event that requires immediate action.
- <u>Warning</u>: Event that requires immediate action because it is or has the potential to become a life/mission threat.
- <u>Caution</u>: Event that needs attention, but not immediate action.

## HERA Evaluation

The purpose of this evaluation was to test the alerts in an analog environment during a realistic task of completing a procedure.



Figure 3. Human Exploration Research Analog (HERA) at the NASA JSC.

### Subjects
- N = 6
- Normal hearing
- Recruited through the Test Subject Facility

### Method
*Stimuli*
- Tone alerts as currently defined by the HSIR.
- Speech alerts using word repetitions specific to the alert type.

*Task*
- Participants completed a realistic task while alerts played in the background at predetermined intervals not disclosed to the participants.
- When an alert occurred, participants indicated the type of alarm (caution, warning, fire, depressurization) using the Alarm Response survey.
- After identifying the type of alarm, participants responded to the alert by following the instructions provided in the alert. This involved retrieving a code located in various locations around the HERA habitat.



Figure 4. The internal setup of the HERA facility.

## Results

A repeated measures ANOVA was conducted on the response time to the alerts. There was a significant main effect of Alarm Type, $F_{(1,5)}$ = 19.29, $p$ = 0.007, indicating faster responses to speech than to tone. There was no significant main effect of Category and no Alarm Type x Category interaction.

Five out of six participants responded faster to speech than tone alarms with a mean difference of 4.8 seconds. The sixth participant had almost the same response time to both types of alerts.

Participants were, on average, 88% accurate identifying tone alarms, and 100% accurate identifying speech alarms for all categories. Participants made errors identifying the caution, warning, and depress tone alarms.

## Recommendations

Speech alerts have been used in aviation and are required in building codes as fire alerts in addition to the use of tones. They are recommended for use in space habitats and space flight due to the higher accuracy and faster identification than tone alerts, either on their own or in combination with tone alerts.